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ABSTRACT

The variables selected to explore some of the determinants of students' decisions to take or not to take mathematics include measures of one's expectancy for success in mathematics, measures of the incentive value of taking the courses, and measures of selected mediating variables. Seventh and ninth graders of both sexes were tested. Two predictions of results can be made: (1) incentive values and expectancies will drop with age for girls while remaining constant or increasing for boys; and (2) sex differences will be less extreme for seventh graders than for ninth graders. (Author/MK)

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Developmental shifts in expectancies and attributions for performance in mathematics

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Researchers studying sex differences in mathematics achievement have consistently reported superior performance by boys as compared to girls (Aiken, 1976; Maccoby & Jacklin, 1974). However, many of the relevant studies have failed to control for the number of mathematics courses taken. Thus, males who have taken more mathematics courses are often compared with females who have taken fewer courses. It has been suggested by Fennema and Sherman and others (Fennema, 1976; Fennema & Sherman, 1977; Fox, 1976) that differential course taking by males and females accounts for a large portion of the sex differences found on test scores. When the number of years studying math is equated for males and females, the differences typically found on high school achievement tests between the sexes are few.

The purpose of this present research project is to explore some of the determinants of the decision to take or not to take mathematics. In most schools, students have the choice of whether or not to continue in math after one year of high school math. Some of the factors which influence this decision might be impossible to change, such as parents' education or their present careers. However, some factors influencing students' decisions to take math may be modifiable. Having identified these factors, one could intervene and increase the likelihood of students continuing to take mathematics so that later remediation would be less necessary.

The variables selected for study were derived from an expectancy/value model of behavior. This psychological model, based in part on decision, achievement, and attribution theories (e.g., Atkinson, 1964; Edwards, 1954; Weiner, 1972), links behavioral choice to both one's expectancy for success in that task and the incentive value of the task for the individual. Applying this expectancy/value model of behavior to students' decisions to continue taking mathematics, we propose that these decisions are jointly influenced by students' expectations for their performance in a particular math course (i.e., how well they expect to do) and by students' perceptions of the importance or incentive value of math achievement. In addition, our research identifies for study a number of other variables believed to mediate and account for individual differences in students' expectancies for success and perceptions of the relative value of various behavioral options. These mediating factors are shown in Table 1 and include: students' appraisals of their own math ability and subject matter difficulty, their perceptions of the expectations of significant others, their sex-role values, their perceptions of the "cost of success", and their future educational or vocational plans. Note that many of these factors are highly influenced by, if not a result of, socialization processes in the home and school. By establishing the respective roles of these mediating factors in students' enrollment decisions, parents and educators could then intervene and increase the likelihood of students continuing to take mathematics so that later remediation would be less necessary.

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Insert Table 1
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Let me enumerate the implications of this model for our understanding of sex differentiated course selection, in particular, of females and their selection of math courses. The model assumes that the effects of experience, namely past history of grades in math, are mediated by the individual interpretation of those events rather than the events themselves. For example, doing well in math will influence one's expectancies only to the extent that doing well is attributed to one's ability and one's stable long term estimate of the difficulty of math for oneself. This assumption seems particularly relevant to the topic of math participation. Girls do as well at math as boys throughout their formative school years yet they do not expect to do as well nor are they as likely to go on in math. This apparent paradox makes sense if we acknowledge that it is the subjective meaning and interpretation of one's successes and failures that determine our perceptions of the task and not the objective outcomes themselves.

Note also that this model assumes that the decision to take math is made in the context of a variety of choices and that whether or not one will take math is dependent on the approach value of math relative to the approach value of all these other choices. Thus, if a girl likes math but feels that the amount of effort it will take to do well is not worth it because it will prevent her from engaging in other more preferred activities, then it is likely that she will not take math courses.

The study to be described here is a part of an extensive project designed to test the expectancy/value model in general and to evaluate its utility in explaining sex differences in particular. Questions assessing the expectancies for mathematics, the incentive value of mathematics, and the proposed mediators were given to students in seventh and ninth grades. The junior high school years were used because they are believed to be critical in the development of attitudes toward math. The attitudes of the ninth grade students were compared to those of the children in the seventh grade where sex differences in math achievement and attitudes are not typically found (Fennema, 1976). In addition, the attitudes of high expectancy children were compared to the attitudes of children with middle and low levels of expectancy.

The subjects in this study were drawn from five junior high schools in a small midwestern city. There were 121 seventh graders (57 boys, 64 girls) and 131 ninth graders (59 boys, 72 girls). Questionnaires assessing attitudes toward math were administered in two class sessions.

This paper focuses on one of the factors believed to influence

students' course selection -- their math achievement expectation -- and on the factors shaping students' math achievement expectations. Specifically, we will discuss:

(1) the degree to which grade, sex and past grades affect students' perceptions of their math ability, math achievement expectancies, attributional patterns and course plans;

(2) the degree to which students' expectancies relate to the proposed mediators of expectancy; their perceptions of math ability, task ability, their attributions for success and failure, and the expectancies of parents;

(3) the explanatory power of students' math achievement expectancies and its mediators in predicting course plans.

The variables relevant to the preceding discussion are summarized in Table 2. Each of the eight variables (#1-4 and 7-10) is measured by a summary index of the questionnaire items listed to the right. The items making up these indices each consist of the stem listed, followed by a 7 point Likert scale with endpoints labeled appropriately. Variable five is measured by an eight point scale from "I very definitely would take more math" to "I very definitely would not take any more math". Variable six is the student's previous year's math grade as recorded in her/his transcript. A student's attributions for success and failure in math achievement situations were measured through the rank ordering of suggested attributions (for examples of each situation see appendix).

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Insert Table 2
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First I would like to discuss the grade and sex differences that were found for the proposed mediators of expectancy. Two by two analyses of variance were done with sex and grade as the independent variables and each of the following as dependent variables: students' current expectancies, future expectancies, perceptions of their math ability and of the difficulty of current and future math courses as well as perceptions of their parents' estimates of their math ability, their parents' estimates of the difficulty of math for them, and their parents' expectations for their success in math. Table 3 presents F and p values for all significant findings. The seventh and ninth graders differed in their perceptions of the difficulty of future math courses with ninth graders rating math more difficult than seventh graders. Ninth graders also received lower math grades in the previous school year than did seventh graders. This may account for their perception that math is and will continue to become more difficult. Several sex differences were found. Compared to girls, boys rate their math ability as higher and perceive their parents as

having higher estimates of their ability even though there is no difference between the past math grades of these same boys and girls. In addition, boys rate both their current math courses and advanced math courses as easier than do girls. Boys and girls do not differ in their perceptions of their parents' expectancies for them nor in their perceptions of their parents' estimates of the difficulty of current math courses. In looking at the expectancies these students have for their performance in math, we find that there is no sex differential for expectancies for success in their current math grades but boys do have higher expectancies than do girls for success in future math courses. Both girls and boys may base their current expectancies on recent objective evaluations of their performance, i.e., last years's math grade. But expectancies for the future may depend not only on these objective outcomes, but also on their perceptions of their own ability and how difficult they view math. And, as was mentioned earlier, boys and girls perceive both of these factors differently. These differing perceptions should be reflected in the attributions assigned to success and failure experiences.

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Insert Table 3

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Boys and girls do differ in their attributional patterns for success and failure in math achievement situations. Boys differ in their use of ability as an explanation for success [median rank (MR) = 4] and failure (MR = 6); i.e., they rank ability as more important for success than for failure, while girls do not (MR = 5-6 in each case.). Girls differ in their use of consistent effort as an explanation for success (MR = 3) and failure (MR = 5) while boys do not (MR = 4 in each case). Chi square tests of sex by the rankings of each attribution show that boys attribute failure less to ability (MR = 6) than do girls (MR = 5) ($X^2 = 9.76$, $p < .05$) and boys attribute success more to ability (MR = 4) than do girls (MR = 6) ($X^2 = 7.99$, $p < .05$).

In addition, girls attribute success more to consistent effort (MR = 3) than do boys (MR = 4) ($X^2 = 8.80$, $p < .05$). When students are divided into expectancy groups, dependent on whether their expectation for success in current math course is low, medium, or high, this difference between boys' and girls' attributions is especially true for high expectancy students. Within the high expectancy group, girls attribute their failure more to lack of ability (MR = 7) and their successes less to ability (MR = 5) than do boys (MR = 8 and MR = 3) ($X^2 = 6.95$, $p < .05$). High expectancy girls also attribute their success more to consistent effort (MR = 3) than do boys (MR = 4) ($X^2 = 11.03$, $p < .05$).

These differences in attributional patterns seem to reflect very different perceptions of the task demands of math which may affect a student's expectations for future success. The girl, for whom

consistent effort is more important than ability as a factor in success, could have low future expectancies because future courses are considered more difficult, demanding even more effort. The amount of effort a student can or is willing to expend has limits and may, in turn, lower their expectancies for future success in math and, in some cases, help them decide not to take math. The same limits would not apply to a boy who views his ability rather than effort as relatively more important for success in math. He might think that his ability will allow him to perform with little or no additional expenditure of effort.

Finally we look at the effect of expectancies and its proposed mediators on willingness to take math coursework. The first order correlations between these variables are presented in Table 4. In the model we propose the effect of sex and previous grades on course plans is to a large part indirect through their effect on expectancies and its mediators. Figure 1 is a path diagram which represents graphically the postulated causal relationships between the variables included in the expectancy half of the expectancy/value model. In this model sex, grade level, and past math grades are exogenous variables, that is they are student characteristics brought to this study and we make no attempt to explain these variables causally. Of the mediator variables, we propose that the students' perceptions of their parents' attitudes are prior to their self perceptions which in turn contribute to their expectations for math success. Expectancies should explain a major portion of the variance in the decision to continue in math.

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Insert Table 4 and Figure 1
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To test this model a series of regression equations were performed with each variable regressed on the set of variables to its left. The standardized beta weights derived from the appropriate regression analyses are the path coefficients that you see in Figure 1. The path diagram pictured in this figure is a reduced path model since only path coefficients significant at $p<.05$ are represented. The path coefficient represents the relationship between the two variables connected by the arrow after the effect of all variables listed to the left are partialed out. Next to the path coefficient, in parentheses, is the zero order correlation between the same two variables. The difference between the path coefficient and the zero order correlation represents the total indirect effect of the predictor variable on the variable it is predicting. This indirect effect could be due to the relationship of the causal variable to either succeeding or prior variables.

Let me point out a few things that we find particularly significant about the results of the path analysis. The effect of

future expectancy on plans to take math courses is to a great part a direct effect (.52 - .44) and in addition, future expectancy is the most important predictor of course plans. This is reflected in the fact that, compared with the other predictor variables, it has both the highest zero order correlation with course plans and the highest path coefficient to plans. Current expectancy, which has the next highest correlation (r=.37) with course plans has no significant direct effect on plans. The large indirect effect of current expectancy must be mediated by its relationship to future expectancy as well as by its relationship to variables preceding it. Previous math grades is shown to have small direct effects on perceived parent estimates of difficulty and ability but has no relationship with plans. Past grades, in fact, contributes very little to this path analysis. The same model without grades shows no appreciable differences in the magnitude of reported path coefficients. This analysis also shows that the effect of sex on course plans is not a direct effect but is mediated by expectancies of future success and perceptions of task difficulty.

The proposed model does seem to do a good job of explaining these data. The variables included in the model explain 46% of the variance in plans to take math. The path diagram shows graphically that plans are indeed effected by future expectancies which are mediated by current expectancies which are mediated, in turn, by one's perceptions of one's ability and task difficulty. This would suggest that a good intervention program to promote higher math participation should focus on heightening girls' expectancies for success in math achievement situations as well as promoting more realistic estimates of task difficulty.

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TABLE 1

Mediators of Student's Expectancies for Success and Incentive Values

Mediators of Expectancies	Mediators of Incentive Values
Perceptions of one's ability	Sex role values
Perceived task difficulty	Cost of success
Causal attributions for success and failure	Future educational and vocational plans
Perceptions of the expectancies of significant others	

TABLE 2

Research Variables

Variable	Questionnaire Items Used to Assess Variable
1. Perception of own math ability	How good at math are you? If you were to order all the students in your math class from the worst to the best in math, where would you put yourself? In comparison to most of your other academic subjects, how good are you at math?
2. Perception of the difficulty of current math course	How hard is math for you? Compared to most other students in your class, how hard is math for you? Compared to most school subjects that you take, how hard is math for you?
3. Current expectancies for own math performance	Compared to other students in your class how well do you expect to do in mathematics this year? How well do you expect to do on your next math test? How well do you think you will do in your math course this year?
4. Future expectancies for own math performance	How well do you think you'll do in your mathematics course? How successful do you think you'd be in a career which required mathematical ability? How well do you think you will do in advanced math courses?
5. Intention to take more math	Would you take more if you didn't have to?

TABLE 2 (cont'd.)

Research Variables

Variable	Questionnaire Items Used to Assess Variable
6. Previous math grade	Final grade received in mathematics (June 1977) -- not available for fifth graders.
7. Perceptions of parents' beliefs about own ability	How good at math does your mother(father) think you are?
8. Perceptions of parents' expectancies	How well do you think your mother(father) expects you to do in math this year?
9. Perception of parents' beliefs about current difficulty	How hard does your mother(father) think math is for you!?
10. Perception of difficulty of advanced math courses	How hard does your mother(father) think advanced high school math will be (is) for you?

TABLE 3

Significant Results[a] of Sex by Grade Analyses of Variance on Expectancy Variables and Their Mediators

	Grade		Sex	
Variable	$F_{1, 227}$	$p <$	$F_{1, 227}$	$p <$
Students' perception of:				
Parents' beliefs about their ability	.61	n.s.	2.59	$p < .10$ M>F
Parents' beliefs about current difficulty	.06	n.s.	.96	n.s.
Parents' expectancies for student	.28	n.s.	.13	n.s.
Own math ability	1.16	n.s.	2.49	$p < .10$ M>F
Difficulty of current math course	2.15	n.s.	6.76	$p < .01$ F>M
Difficulty of future math courses	8.00	$p < .01$ 9th>7th	6.64	$p < .01$ F>M
Previous math grade	17.90	$p < .01$ 7th>9th	.86	n.s.
Current expectancy for own math performance	1.94	n.s.	1.35	n.s.
Future expectancy for own math performance	.05	n.s.	6.68	$p < .01$ M>F

[a]There were no significant sex by grade interactions.

TABLE 4

Intercorrelation Matrix of Course Plans and Its Predictors

	Course Plans	Sex	Grade Level	Past Grades	Parent Expectancy	Parent Difficulty	Parent Ability	Future Difficulty	Current Difficulty	Perceived Ability	Current Expectancy	Future Expectancy
Course Plans	1.00											
Sex (1-Female, 2-Male)	.05	1.00										
Grade Level (7,9)	.34	.00	1.00									
Past Grades	-.00	-.07	-.29	1.00								
Parent Expectancy	.29	-.02	-.03	.10	1.00							
Parent Difficulty	-.22	-.07	.02	-.17	-.28	1.00						
Parent Ability	.35	.11	.06	.21	.52	-.41	1.00					
Future Difficulty	-.16	-.17	.19	-.10	-.22	.31	-.21	1.00				
Current Difficulty	-.28	-.17	.10	-.20	-.30	.49	-.51	.58	1.00			
Perceived Ability	.37	.11	.07	.24	.44	-.41	.72	-.37	-.69	1.00		
Current Expectancy	.37	.08	-.08	.22	.48	-.35	.63	-.34	-.60	.80	1.00	
Future Expectancy	.52	.17	.01	.14	.54	-.32	.57	-.38	-.52	.67	.62	1.00

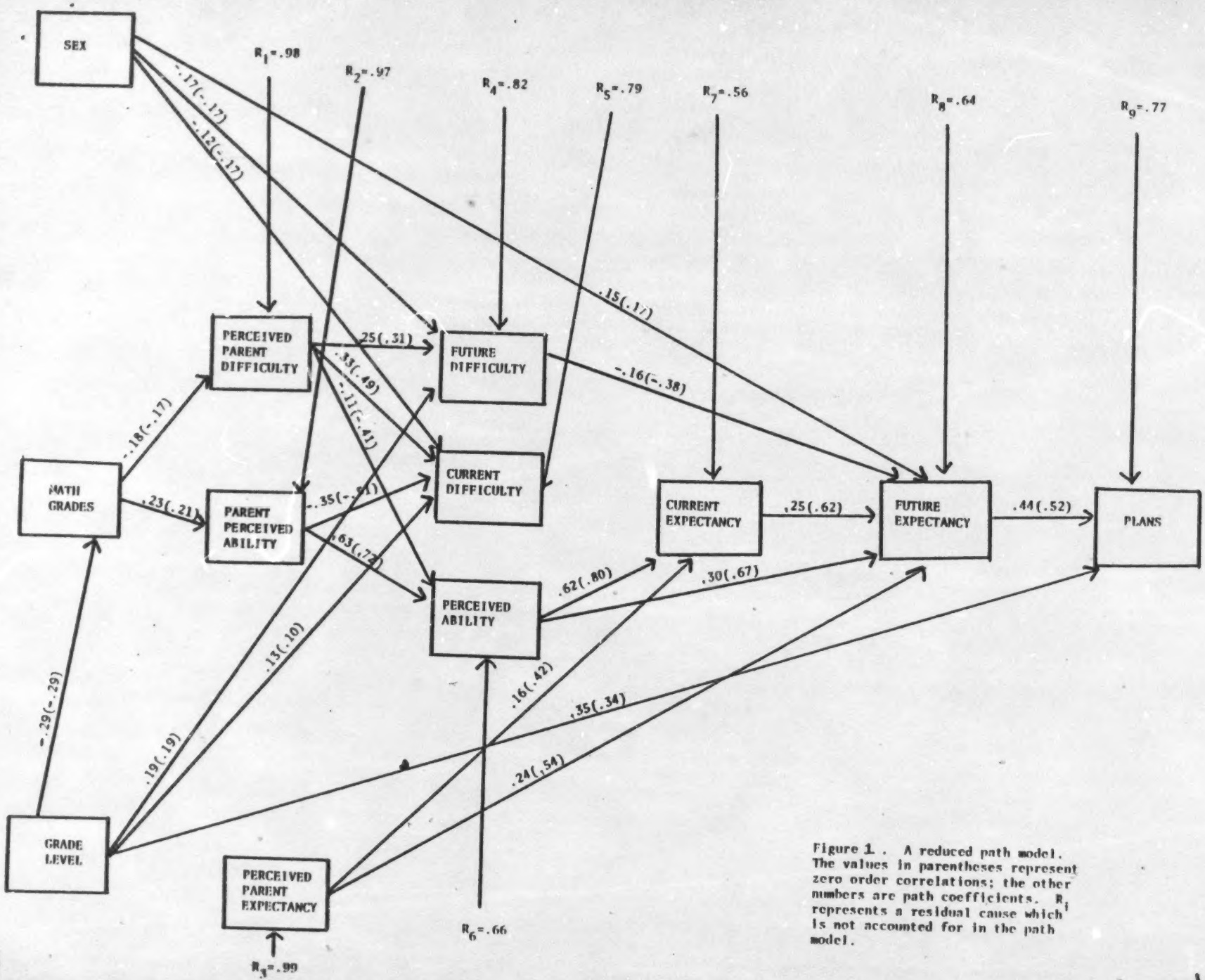

Figure 1. A reduced path model. The values in parentheses represent zero order correlations; the other numbers are path coefficients. R_i represents a residual cause which is not accounted for in the path model.

APPENDIX

Now we are going to give a list of reasons that students often give for why they have done poorly on a math test. Think about the times when you didn't do very well on a math test. Read the list. Then answer the questions at the bottom of the list.

a) I did poorly on the math test because I am not very smart in math.

b) I did poorly on the math test because my teacher did not give me as much help as I needed.

c) I did poorly on the math test because my parents did not give me as much help as I needed.

d) I did poorly on the math test because I don't like math very much.

e) I did poorly on the math test because I have not worked very hard in math this year.

f) I did poorly on the math test because I didn't study hard enough for the test.

g) I did poorly on the math test because the math test was hard.

h) I did poorly on the math test because I was not feeling very good at the time I took the test.

Pick the reason <u>you</u> think is the most important reason for why you did so poorly on that test. Write the letter of that reason here _____. Now cross out that reason with your pencil.

Now pick the reason <u>you</u> think is the <u>next most</u> important reason and write its letter here _____ Cross out the reason.

Now pick the reason <u>you</u> think is the <u>third most</u> important reason and write its letter here_____ Cross out the reason.

Now pick the reason <u>you</u> think is the <u>fourth most</u> important reason and write its letter here _____ Cross out the reason.

Now pick the reason <u>you</u> think is the <u>fifth most</u> important reason and write its letter here _____ Cross out the reason.

Now pick the reason <u>you</u> think is the <u>sixth most</u> important reason and write its letter here _____ Cross out the reason.

Now pick the reason <u>you</u> think is the <u>seventh most</u> important reason and write its letter here _____ Cross out the reason.

We are going to give a list of reasons that students often give for why they have done well on a math test. Think about a time when you did very well a math test. Read the list. Then answer the questions at the bottom of the list.

a) I did well on the math test because I am smart in math.

b) I did well on the math test because my teacher helped me learn the math.

c) I did well on the math test because my parents helped me learn math.

d) I did well on the math test because I like math so much.

e) I did well on the math test because I have worked very hard on my math all year.

f) I did well on the math test because I studied very hard for the math test.

g) I did well on the math test because math tests are easy.

h) I did well on the math test because I was feeling so good at the time I took the test.

Pick the reason you think is the most important reason for why you did so well on that math test. Write the letter on that reason here _____ Now cross out that reason with your pencil.

Now pick the reason you think is the next most important reason and write its letter here _____ Cross out the reason.

Now pick the reason you think is the third most important reason and write its letter here _____ Cross out the reason.

Now pick the reason you think is the fourth most important reason and write its letter here _____ Cross out the reason.

Now pick the reason you think is the fifth most important reason and write its letter here _____ Cross out the reason.

Now pick the reason you think is the sixth most important reason and write its letter here _____ Cross out the reason.

Now pick the reason you think is the seventh most important reason and write its letter here _____ Cross out the reason.